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IS 10471 (1983): Recommended practice for corrosion prevention in electronic component and assemblies [MTD 24: Corrosion Protection]



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Indian Standard

RECOMMENDED PRACTICE FOR
CORROSION PREVENTION IN ELECTRONIC
COMPONENT AND ASSEMBLIES

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RECOMMENDED PRACTICE FOR CORROSION PREVENTION IN ELECTRONIC COMPONENT AND ASSEMBLIES

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Indian Standard

RECOMMENDED PRACTICE FOR CORROSION PREVENTION IN ELECTRONIC COMPONENT AND ASSEMBLIES

0. FOREWORD

0.1 This Indian Standard was adopted by the Indian Standards Institution on 29 January 1983, after the draft finalized by the Corrosion Protection Sectional Committee had been approved by the Structural and Metals Division Council.

0.2 Electronic components and assemblies are used in a variety of environments possessing varying magnitude of corrosivity. The high degree of performance and precision achieved in the field of electronics is quite often nullified by failures caused by corrosion of electronic components. Therefore, a standard which establishes the minimum requirement for corrosion control in electronic components is a prerequisite to maintain a factor of higher reliability. Such a standard can also be used as a comprehensive guide for selection of materials and protection measures.

0.3 The purpose of this standard is to establish the requirements for the corrosion control of electronic components and to serve as an aid in selection of materials as well as corrosion control procedures. Compliance with this standard will minimise the corrosion failures in electronic components and assemblies.

0.4 This standard does not attempt to explain the corrosion mechanism and does not cover all the eventualities leading to failures which may arise in a practical situation.

0.5 While preparing this standard, assistance has been derived from the following overseas publications:

- a) MIL STANDARD 1250 (MI) of 1967, U.S.A.
- b) 'Proceedings of the Triservice Conference on Corrosion' Published by Metals and Ceramics Information Centre, Battele, 1972, U.S.A.

- c) 'Marine Corrosion, Causes and Prevention, by F.L. Laque, John Wiley, 1975.
 - d) 'Protective Coatings for Metals' by R.M. Burnes and W.W. Bradley, Reinhold, 1967.
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1. SCOPE

1.1 This standard covers recommendations for prevention of corrosion of metallic materials in electronic components and assemblies. It does not deal with the electronic uses of non-metallic materials, such as plastics, composites, elastomers and other polymeric materials.

1.2 The scope of this standard is limited to the anticorrosive performance of metallic materials used in electronic components and related corrosion control measures.

1.2.1 This standard does not cover electrical or mechanical design except those aspects which affect susceptibility towards corrosion.

1.2.2 This standard however does not debar the use of other proven commercial material or process selected and concurred by the procuring agency or authority.

2. TERMINOLOGY

2.0 For the purpose of this standard, the following definitions, in addition to those given in IS: 3531-1966* shall apply.

2.1 Case Corrosion — A type of corrosion over the surface of component case (for example, the case of a capacitor) which obliterates identification of markings making it difficult for replacement or repair of circuit.

2.2 Element Corrosion — Corrosion under a coating which progresses by entry of moisture through wicking action along metal lead (for example — corrosion of wire wound fixed resistors).

2.3 Bimetallic Corrosion — Corrosion of metallic couples due to galvanic action through the electrolyte.

2.4 Contact Corrosion — Corrosion at contact of electro-mechanical devices such as relays and switches caused by build up of contaminants or by corrosion product across an insulation barrier.

*Glossary of terms relating to corrosion of metals.

2.5 Lead Wire Corrosion — A form of corrosion failure in respect of lead wires which corrode near proximity to the part body resulting in necking or growing.

2.6 Hermetic Seal — An impervious seal made by fusion of metals or ceramic materials by brazing, soldering, welding or fusion which prevents the passage of gas or moisture.

2.7 Purple Plague — A brittle gold-aluminium compound formed in the presence of silicones.

2.8 Red Plague — A copper oxide corrosion product found on silver plate over copper at pinholes or breaks.

2.9 Silver Migration — The migration of silver from one conductor in a circuit to another which is at different electrical potential across ceramic or plastic insulation under humid conditions.

3. CORROSIVE ATMOSPHERE

3.1 General — It is of prime interest to user or manufacturer to identify the atmosphere in which the equipment will be put to use. Synergistic effects of particulate matter, corrosive gases, humidity and temperature should be taken into account.

3.1.1 Atmospheres vary with respect to moisture, temperature and contaminants. In the proximity of seacoast the atmosphere is laden with increasing amount of sea salts, which promote and accelerate corrosion. In the industrial areas, gases containing oxide of sulphur, nitrogen and suspended particulate matter are encountered.

3.1.2 Metals in the atmosphere tend to form oxide scale which possesses higher electrical resistivity compared to base metals. Rate of oxide formation is influenced by temperature. Metal surface at high humidity tends to become wet or retain moisture. Particulate matter and atmospheric gases catalyse formation of electrolytic corrosion products. Protective qualities of the metal/metal oxide surface are liable to degrade under high humidity condition and high degree of suspended matter.

3.2 Moisture — Moisture in the electronic assemblies adversely affects the corrosion resistance of metals. It encourages growth of microorganisms such as fungi and bacteria. Presence of fungi and bacteria accelerates the localised corrosion process.

3.2.1 Adequate housings, seals, gaskets and closures shall be used to exclude moisture from the equipment. Electronic components shall be preserved at temperature above dew point.

3.2.2 Pockets, traps and sump areas where moisture may be trapped or collected shall be avoided.

3.2.3 Hygroscopic materials shall not be used in the electronic equipment.

3.2.4 Dessicants shall not be used unless necessary for moisture level control. Dessicants, if used, shall not be in contact with the unprotected part of the equipment.

3.3 Atmosphere in the Equipment — The design and construction of the equipment shall incorporate techniques such as protective coating, encapsulation, evacuation, hermetic sealing, filtering of air, removal of moisture and air borne corrodents to ensure lowest possible corrosivity.

3.3.1 Where forced cooling is necessary to maintain equipment at permissible operating temperature, moisture and airborne contaminants shall be removed externally before cooling air passes over electronic components.

4. SELECTION OF METALS

4.1 General — Suitability for the purpose and inherent corrosion resistance shall be of prime consideration while selection is done. Unless otherwise specified, the surface of the metals shall be smooth, bearing no crevices and scratches. Metals shall be compatible with each other and shall not produce outgas or fumes on welding and brazing. Compatibility of metals may be ascertained by referring to Table 1. Corrosion resistance may be determined using neutral salt spray test.

4.1.1 All metals shall be thoroughly cleaned before joining, casting, rolling, impregnating or encapsulating. Cleaning of surface shall be done after welding, brazing or soldering.

4.1.2 Steels shall not be cathodically cleaned either in acid or alkali except anodic cleaning.

4.1.3 Organic solvents shall be used with care to avoid contact with plastic or polymeric materials.

4.1.4 Vapour degreasing shall be done in accordance with procedures laid down in IS : 3194-1980*.

4.1.5 All cleaning materials shall be compatible with parts or components of the assembly (*see* Table 1).

*Recommended practice for cleaning of metals prior to electroplating (*first revision*).

TABLE 1 COMPATIBILITY OF MATERIALS(*Clauses 4.1, 4.1.5, 7.2.2 and 9.4*)

MATERIALS	INCOMPATIBLE ENVIRONMENT/ MATERIAL
Copper, iron, manganese	Rubber, acid
Cadmium	Organic vapours
Silver	Sulphide bearing atmosphere and polymeric materials
Copper, brass, tin, lead, tin-lead, aluminium, zinc, magnesium, gold coating over copper alloys	Polyvinylchloride
Copper, brass, silver	Paper, cardboard
Copper, brass, cadmium, humidity indicators containing cobalt salts	Ammonia
Acrylic, alkyd, cellulosic, polyamide, polyester, polyethylene polyurethane polymeric materials	Acids
Acryline, alkyd, cellulosic, polyesters	Alkali
Acrylic, cellulosic, polycarbonates, polystyrene	Hydrocarbon solvents
Vinyl, neoprene	Diester oils, ketonic solvents
All organic coating used in electronic assemblies	Silicon oils and greases

4.1.6 Dust, dirt and finger prints shall be removed prior to assembly storage.

4.1.7 Contact leads should be of corrosion resistant metal to avoid end seal migration.

4.1.8 Metals which are inherently resistant to tarnish and oxidation shall be selected. Metals, prone to tarnishing, shall be protected from oxidation by plating with noble metals listed in Table 2 or by suitable non-insulating coating given in Table 3.

4.2 Conjoint Action of Stress and Corrosion — Metals and alloys which are resistant to stress corrosion and intergranular corrosion shall be selected where residual and induced stresses are involved. After mechanical working, such as bending, shaping and forming, annealing shall be carried out to remove residual stresses.

TABLE 2 SELECTION OF CORROSION RESISTANT METALLIC COATINGS(*Clauses 4.1.8, 5.2 and 8.1*)

PURPOSE	RECOMMENDED COATING	COATING NOT RECOMMENDED
Contact with aluminium and magnesium	Cadmium, tin	Chromium, copper, silver, gold
Prior to painting	Cadmium, tin	Chromium, copper, nickel, gold, silver
Tarnish prevention	Nickel between copper and silver, gold over silver, copper and nickel, rhodium over silver	
Marine exposure	Passivated cadmium coatings	
Solderability	Tin, gold or tin lead	Nickel, chromium, rhodium
Storage	Reflowed heavy tin, gold or rhodium	Cadmium silver, copper
Wear	Hard chromium nickel, rhodium	Cadmium, tin
Easy etching for printed circuit board manufacture	Cadmium, nickel, tin	Tin-lead, rhodium, silver, gold

TABLE 3 COMPATIBLE SURFACE FINISHES FOR ELECTRICAL BONDING(*Clauses 4.1.8 and 7.2.4*)

METAL	SURFACE FINISH
Aluminium and aluminium clad alloys	Bare or low electrical resistance chromate type film treatment, tin plating, cadmium plating or nickel cadmium plating
Copper and copper alloys	Bare or tin plate, cadmium plating preferred
Cadmium	Bare or chromate treated
Iron and steel	Tin coating, tin lead plating, cadmium coating preferred
Nickel and corrosion resistant steels	Bare, difficult to bonding because of adherent oxide film
Silver	Bare
Tin	Bare

4.3 Hydrogen Embrittlement—Metals and alloys which are not susceptible to delayed fracture due to hydrogen pickup shall be given preference. Metals and alloys susceptible to such delayed fracture are to be coated by organic coating or vacuum deposition of resistant metals.

4.3.1 Where electroplating is a necessity, the components shall be embrittled relieved at $190^{\circ} \pm 14^{\circ}\text{C}$ for a minimum period of three hours.

4.3.2 Where practicable parts shall be mechanically stress relieved by shot peening in accordance with IS : 7001-1973*.

4.4 Whisker Growth—Tin, cadmium and iron are susceptible to whisker growth in humid atmosphere. Whisker growth shall be minimized by use of heavier metal coating within permissible limits. Hot dip process of deposition, reheating of deposits, by shot peening and maintaining low level of humidity may be judiciously used.

4.5 Silver Migration—Silver migration shall be minimized by the following techniques as applicable.

4.5.1 Spacing between conductors at different voltages shall be as wide as possible.

4.5.2 Conductors shall be protected by organic coatings where permissible.

4.5.3 Contaminants shall be removed by forced air drying.

4.5.4 Where practicable tin-lead, gold and platinum coatings shall be used.

4.5.5 Non-hygroscopic insulation shall be used.

5. TREATMENT OF FERROUS PARTS FOR CORROSION PREVENTION

5.1 All carbon steels shall be passivated in accordance with IS : 6005-1970†.

5.1.1 Precipitation hardenable steels shall be given one coat of zinc chromate primer (see IS : 104-1979‡) followed by a suitable top coat.

*Method for shot peening and test for shot peened ferrous metal parts.

†Code of practice for phosphating of iron and steel.

‡Specification for ready mixed paint, brushing, zinc chrome, priming (second revision).

5.2 Metallic Coating — Where applicable, carbon steels shall be coated with cadmium, tin and nickel as applicable (*see* Table 2).

5.3 Carbon steel parts, which are totally and continuously immersed in oil or contained in a heremetically sealed unit, shall not be coated.

5.4 Laminations used in magnetic circuits shall not be plated or coated.

5.5 Organic coatings or lacquers shall be preferred in respect of springs and component cases which are prone to case corrosion.

5.6 Contact corrosion may be avoided by use of thick nickel plating.

6. TREATMENT OF NON-FERROUS PARTS FOR CORROSION PREVENTION

6.1 Aluminium — Anodizing of aluminium parts shall be done in accordance with IS : 7088-1973* after punching, drilling, machining, forming and any other fabrication work is completed.

6.1.1 Anodizing shall not be carried out in areas of electrical bonding.

6.1.2 Electrical bond areas shall be suitably masked before anodizing.

6.1.3 Chromate type anodizing process shall be applied where masked bond is involved.

6.1.4 Other metallic coatings such as electroless nickel shall be considered for applications, involving high temperatures such as heat-sinks.

6.1.5 Aluminium components may be treated for a conversion coating of either chromate/phosphate or chromate/boride type depending on the electrical conductivity requirement for the treated components.

6.2 Copper — Copper possess a good degree of corrosion resistance to atmospheric corrosion. Where tarnish prevention is a necessity, polyurethane or silicone cured resin films may be used. Silicone oils and greases shall not be applied.

6.3 Magnesium — Magnesium possess poor resistance to corrosion. Where magnesium is intended to be used, approval for specific application shall be obtained prior to its design incorporation from the competent authority.

*Recommended practice for anodizing aluminium and its alloys.

6.3.1 Use of magnesium based alloys shall not be recommended in tropical atmospheres.

6.3.2 Prior to its incorporation in the electronic assembly, magnesium parts shall be anodized and shall be given two coats of alkali resistant primer followed by a compatible top coat.

6.3.3 Extreme precautions shall be taken at magnesium metal contacts to avoid destructive corrosion. Where practicable aluminum alloy gasket shall be interposed between two metals. In case use of gasket is not practicable, the joint shall be sealed with moisture proofing compound.

7. CORROSION PREVENTION AT DISSIMILAR METAL CONTACTS

7.1 General — Metals having different emf in the galvanic series are prone to corrosion due to galvanic action. Initiation and propagation of corrosion at dissimilar metal contacts takes place in presence of condensed water acting as electrolyte. Anodic member of the couple is seriously corroded.

7.1.1 Dissimilar metals having wide difference of emf [in the galvanic series] shall not be used for contacts unless fully protected.

7.1.2 Effort shall be made in design to avoid collection of moisture/electrolyte at metallic contacts.

7.1.3 Where necessary, dissimilar metals shall be selected from the permissible couple, as given in Table 4.

7.1.4 Metallic contact implies the contact between the two metallic materials existing on surfaces; for example, contact between copper coated with nickel and copper coated with silver implies contact between nickel and silver.

7.1.5 Joining metal shall not be anodic to the metal being joined.

7.1.6 Electrically conducting graphite shall be considered as metal for the purpose of determining galvanic compatibility.

7.2 Joining of Metals — Due consideration shall be given to possible corrosion due to galvanic action while making a choice of joining method. Table 4 may be referred as a guide in selection of solders. Joints shall be continuous and crevices shall be avoided. Preventive measures that should be taken to minimise galvanic corrosion are given in Appendix A.

TABLE 4 PERMISSIBLE GALVANIC COUPLES

(Clause 7.1.3)

ANODIC COMPONENT	CATHODIC COMPONENT
Zinc, zinc alloys and zinc coatings	Hot dip zinc and galvanised steel
Aluminium, cast and wrought alloys other than duralumin	Cadmium plated articles
Aluminium wrought alloys of duralumin type	Wrought iron, malleable iron, armco iron, low alloy steels
Tin plate, tin lead solders, solid lead and lead alloys	Chromium plated articles, martensitic/ferritic stainless steels
Stainless steels, martensitic and ferritic	High brasses, bronzes, naval brass, muntz metal
Commercial yellow brasses and bronzes	Silver solder, german silver, copper-nickel alloys, nickel chrome alloys, austenitic stainless steels
Nickel, monel, titanium high nickel alloys	Silver plated articles, high silver alloys

7.2.1 Crevice Corrosion — Joints where crevices may exist shall be sealed with epoxy or polyurethane based sealant. Marker tapes are to be applied on surfaces suitably coated.

7.2.2 Brazing, Soldering and Welding — Compatible materials as given in Tables 1 and 3 shall be used for joining operations. Soldering over gold shall be avoided where possible. Minimum joining time at minimum possible temperature shall be followed. Lowest acid content flux shall be used. Flux residues shall be removed and thoroughly cleaned.

7.2.3 Formation of purple plague may be avoided by use of copper or silver in lieu of gold.

7.2.4 Surface Finish — Compatibility of surface finishes may be decided by referring to Table 3.

7.2.5 If bonding of dissimilar metals is necessary the bond area shall be coated with epoxy resin sealant.

7.2.6 If metallic washers are used in bonding, washers shall be passivated.

7.2.7 Caution shall be exercised to achieve firm adhesion of the surface finish to avoid element corrosion.

8. USE OF METALLIC COATINGS

8.1 General — Anticorrosive performance of metallic coatings is dependant on its adherence to substrate metal, porosity and uniformity of thickness. Attention shall be given to the cracks in coatings. Where possible the coatings shall be tested using neutral salt spray test method. Table 2 may be used as an aid to choose metallic coatings. The recommended minimum thickness for different types of electroplated coatings are given in Table 5 for guidance.

**TABLE 5 RECOMMENDED MINIMUM THICKNESS FOR
ELECTROPLATED METALLIC COATINGS**

(Clause 8.1)

COATING	RECOMMENDED MINIMUM THICKNESS, μ m	REMARKS
Cadmium over mild steel	13.0	For protection under corrosive conditions
Chromium over mild steel and copper	0.3	Generally used for wear resistance
Copper over mild steel	7.5	As an undercoat or for electrical conductance purpose
Gold over copper or silver	0.75	For better electrical contact
Nickel over mild steel	30.0	To avoid contact
Nickel over copper	12.0	Corrosion of components
Tin over mild steel	20.0	For protection under severe conditions
Palladium over silver	0.75	Moderate conditions
Rhodium over silver	0.75	For prevention of tarnish

8.2 Cadmium Coatings — Cadmium may be coated by vacuum deposition or electroplating process. Cadmium coated parts shall not be used in enclosed assembly containing acid, ammonia, plastics, varnishes and other organic materials.

8.3 Chromium Coatings — Chromium coatings shall be used for applications involving wear and not for corrosion resistance.

8.4 Copper Coatings — Copper coatings are prone to red plague type of corrosion which occur at pores or pin holes. Red plague may be avoided by a coat of nickel.

8.5 Gold Coating — Gold shall be preferably coated over thin nickel coating to retard diffusion of substrate metal. Gold plating is prone to purple plague type of corrosion when gold comes in contact with aluminium.

8.6 Nickel Coatings — Nickel coatings are desirable for electrical bonding. Nickel may be coated by electroplating or electroless process. Contact corrosion is minimized by use of nickel coating.

8.7 Palladium Coating — Palladium may be coated by electroplating process. Contact of organic materials shall be avoided to prevent polymerization of organic compounds.

8.8 Silver Coating — Silver may be electroplated. Silver coatings are prone to corrosion in sulphide bearing atmosphere and also prone to silver migration phenomenon. Care shall be taken to avoid sulphurous fumes during storage and precautions shall be taken to avoid silver migration (*see 4.5*).

8.9 Tin Coating — Tin may be coated by hot dipping or electrodeposition process. Tin possess tendency to form metal whiskers. Precautions shall be taken to avoid metal whiskers (*see 4.4*). Lead wire corrosion is minimized by use of tin coating.

8.10 Zinc Coating — Zinc coating shall not be used.

8.11 Vacuum Deposition — Vacuum deposition provide extremely thin coatings, and this technique may not be suitable for mechanical application like moving contact.

9. USE OF ORGANIC COATINGS AND NON-METALLICS

9.1 Corrosion resistant nonmetallic materials shall possess low moisture absorption, resistance to fungi and microbial attack, stability in the specified temperature range, freedom from outgassing, compatibility with other materials in the assembly and resistance to weathering.

9.2 Organic materials shall be thoroughly dried or cured before use.

9.3 Polyvinyl chlorides and chlorinated rubber shall not be used in closed compartments. Where practicable use of neoprene, polysulphides and vinyl resins shall be avoided in closed compartments.

9.4 Compatibility of materials shall be taken into account. Table 1 may be used as a guide for selection of materials.

9.5 Silicone oils and greases are not compatible with organic finishes. These shall not be used without approval of the competent authority.

9.6 Graphite containing solid film lubricant shall not be used.

10. PACKAGING AND PRESERVATION

10.1 Packaging and preservation shall be done in accordance with the procedures given in IS : 8221-1976*.

10.2 Volatile corrosion inhibitors may be used to protect metals against corrosion in accordance with the procedure laid down in IS : 6263-1972†.

A P P E N D I X A

(Clause 7.2)

PREVENTIVE MEASURES TO REDUCE GALVANIC CORROSION AT JOINTS

- A-1. Selection of materials should be made from permissible couple.
- A-2. Fastener should preferably form a cathodic member of the couple.
- A-3. Brazing and soldering material shall be cathodic to the material being joined.
- A-4. Advantage may be derived from the smaller potential difference among the members of couple.
- A-5. The metal contact should be so designed, so that the relative area of cathodic metal is smaller.
- A-6. Where coating is used, it should be applied to both members of the couple.
- A-7. Joints may preferably be sealed by moisture proof coating or sealant.
- A-8. Corrosion inhibitor treatment may be used at joints.

*Code of practice for corrosion prevention of metals and metal components in packages.

†Volatile corrosion inhibitor (VCI) treated paper.